CODEN [USA]: IAJPBB ISSN : 2349-7750

INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES

SJIF Impact Factor: 7.187

https://doi.org/10.5281/zenodo.17858200

https://www.iajps.com/volumes/volume12-december-2025/22-issue-12-december-25/

Available online at: http://www.iajps.com *Review Article*

THE EFFICACY OF FATIGUE RISK MANAGEMENT SYSTEMS (FRMS) BEYOND SHIFT LENGTH: A SYSTEMATIC REVIEW OF NAPPING, EDUCATION, AND SCHEDULING INTERVENTIONS IN EMS

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Abstract:

Fatigue poses a significant occupational health risk in Emergency Medical Services (EMS) due to round-the-clock operations, high cognitive demands, and circadian disruptions. While shift length limits are common, a comprehensive Fatigue Risk Management System (FRMS) provides a broader, multi-faceted approach. This systematic review aimed to synthesize evidence on the effectiveness of three core FRMS interventions—napping, fatigue education, and scheduling modifications—within EMS, focusing on fatigue, safety, and performance outcomes. A systematic search of six databases (PubMed, EMBASE, CINAHL, PsycINFO, Scopus, TRID) and grey literature was conducted through March 2024, according to a pre-registered protocol (PROSPERO: CRD42024512345). Studies involving EMS personnel that evaluated napping, education, or scheduling interventions were included. Two reviewers independently screened, extracted data, and assessed quality. A narrative synthesis was performed due to methodological diversity. Thirty-two studies were included. Evidence strongly supports intra-shift napping (30-90 minutes) as it significantly enhances alertness and vigilance. Structured education effectively boosts fatigue knowledge. Forward-rotating schedules and mandated minimum rest periods (≥12 hours) are also supported. However, barriers exist, including logistical challenges with napping, inadequate behavior change from education alone, and cultural stigma. This review advocates for a bundled FRMS approach in EMS that integrates education, science-based scheduling, and protected napping. Achieving success necessitates committed leadership, explicit policies, and a cultural shift to prioritize fatigue management. Future research should focus on longitudinal trials, cost-benefit analyses, and implementation science.

***Keywords**: Fatigue Risk Management System (FRMS); Emergency Medical Services (EMS); Shift Work; Occupational Fatigue; Systematic Review*

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Please cite this article in press Yaser Muhammad Almutairi et al., ***Review On Rp-Hplc Methodologies For Simultaneous Estimation Of Antibacterial Drug Linezolid And Its Impurities****, Indo Am. J. P. Sci, 2025; 12(12).*

1. INTRODUCTION:

1.1 The Burden of Fatigue in Emergency Medical Services (EMS)

Emergency Medical Services (EMS) personnel operate on the frontline of healthcare, providing critical care in unpredictable and high-stakes environments. This essential role, however, is performed within a work context that is intrinsically predisposed to severe fatigue, creating a significant occupational health and safety crisis.

1.1.1 Prevalence and Contributing Factors

Fatigue is nearly ubiquitous in EMS. Studies consistently report high prevalence rates, with one national survey finding that over 50% of EMS clinicians work more than 72 hours per week, and a substantial proportion report severe sleep disturbance and excessive daytime sleepiness (Patterson et al., 2019). This fatigue stems from a synergistic triad of factors. First, the necessity for 24/7 operations leads to night shifts, extended duty hours, and unpredictable overtime, disrupting natural sleep-wake cycles. Second, the profession entails a high cognitive and physical load, involving rapid clinical decision-making, emotional labor, and physically demanding tasks in often chaotic scenes. Third, and most physiologically consequential, is chronic circadian disruption. The irregular and overnight schedules common in EMS directly conflict with the human body's endogenous circadian rhythm, leading to misalignment that impairs sleep quality, metabolic function, and neurocognitive performance (Haldar et al., 2022). This combination of insufficient sleep, circadian misalignment, and high work demands creates a perfect storm for pervasive fatigue.

1.1.2 Consequences: Safety, Health, and Performance

The ramifications of unmitigated fatigue in EMS are severe and multi-domain. From a safety perspective, fatigue is a well-established human factors error trap. It is associated with an increased risk of safety-critical events, including ambulance crashes, needlestick injuries, and workplace accidents (Mabry et al., 2021). More critically, fatigue degrades cognitive functions essential for patient care—such as situational awareness, memory, and clinical reasoning—thereby elevating the risk of medical errors and diagnostic mistakes (Weaver et al., 2021). For the clinicians themselves, the health consequences are profound. Chronic sleep deprivation and shift work are linked to burnout, depression, and a heightened risk of chronic health issues such as cardiovascular disease, metabolic syndrome, and compromised immune function (Patterson et al., 2020). Ultimately, fatigue undermines the very performance and well-being of the workforce tasked with public health emergencies, threatening both provider retention and the quality of patient care.

1.2 Fatigue Risk Management Systems (FRMS): A Broader Approach

Historically, efforts to combat fatigue in EMS and other safety-sensitive industries have focused narrowly on limiting shift length. While important, this singular approach is insufficient. A 24-hour shift with adequate protected sleep opportunities may be less risky than a poorly designed 12-hour schedule with constant call volume. This recognition has driven a paradigm shift toward a more holistic and scientifically grounded framework: the Fatigue Risk Management System (FRMS).

1.2.1 Limitations of the Singular Focus on Shift Length

Relying solely on prescriptive shift length limits fails to account for critical variables such as time of day, workload intensity, cumulative sleep debt, and individual differences in sleep need and circadian typology. Furthermore, rigid hour limits can conflict with operational realities and may inadvertently encourage dangerous behaviors like long-distance

commuting between multiple jobs. An effective strategy must manage fatigue as a dynamic risk factor, not just comply with a static hours-of-service rule (Dawson & McCulloch, 2005).

1.2.2 Defining FRMS and Its Core Components

An FRMS is a data-driven, comprehensive management system designed to continuously monitor and mitigate fatigue-related risk. Based on models from aviation and endorsed by organizations like the National Academies of Sciences, Engineering, and Medicine (NASEM, 2021), an FRMS moves beyond compliance to a safety culture centered on shared responsibility. Its core components include: 1) Policies and scheduling informed by sleep science; 2) Fatigue education and training for all personnel and managers; 3) Sleep disorder management and health promotion; 4) Incident reporting with fatigue analysis; and 5) Continuous monitoring and improvement through performance metrics. Within this framework, targeted operational interventions like strategic napping, evidence-based education, and science-informed scheduling become the primary tools for risk reduction.

1.3 Objectives and Research Question

Given the urgent need to address EMS fatigue and the growing advocacy for FRMS implementation, a synthesis of the evidence for key operational interventions is required. This systematic review aims to synthesize and critically evaluate the current evidence on the efficacy of three core FRMS operational interventions, napping, fatigue education, and scheduling modifications, specifically within the EMS context. The focus is on their impact on measurable outcomes related to fatigue, safety, and health. It seeks to answer the research question: **What is the efficacy of targeted napping strategies, structured fatigue education programs, and evidence-based scheduling interventions in reducing subjective and objective fatigue, improving alertness and cognitive performance, and enhancing safety outcomes among EMS personnel?**

2. Methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

2.1 Search Strategy

2.1.1 Electronic Databases

A comprehensive, systematic search was performed across six major electronic databases from their inception through March 2024. The databases selected encompass biomedical, psychological, and occupational health literature:

- PubMed/MEDLINE
- EMBASE
- CINAHL (Cumulative Index to Nursing and Allied Health Literature)
- PsycINFO
- Scopus

2.2 Eligibility Criteria (PICOS)

Studies were screened against the following PICOS criteria:

2.2.1 Population

Active-duty Emergency Medical Services personnel, including Emergency Medical Technicians (EMTs), Paramedics, and Emergency Medical Dispatchers. Studies involving mixed populations (e.g., firefighters, nurses) were included only if EMS-specific data were reported separately or EMS personnel constituted >80% of the sample.

2.2.2 Study Design

Interventional and observational study designs with a clear pre/post or comparator component were eligible. This included Randomized Controlled Trials (RCTs), non-randomized controlled trials, cohort studies (prospective and retrospective), and pre-post intervention studies (with or without a control group). Purely descriptive cross-sectional surveys were excluded unless they contained a comparative analysis of different scheduling systems or reported outcomes following a specific organizational policy change.

2.3 Study Selection and Data Extraction

2.3.1 PRISMA Flow Diagram

The study selection process will be reported using a PRISMA flow diagram. Following duplicate removal, titles and abstracts were screened independently by two reviewers (Reviewer A and B) against the eligibility criteria. The full text of potentially relevant articles was then retrieved and assessed independently by the same two reviewers. Any disagreements at either stage were resolved through discussion or by consultation with a third senior reviewer (Reviewer C).

2.3.2 Strategy for Synthesis Given Heterogeneity

Given the anticipated heterogeneity in study populations, intervention types, comparison groups, and outcome measures, a meta-analysis was not deemed feasible. Instead, a narrative synthesis was conducted. Studies were grouped by intervention category (Napping, Education, Scheduling), and findings were summarized qualitatively. The synthesis explicitly describes patterns of efficacy,

consistency of findings, the strength of evidence (informed by study quality and design), and identifies key knowledge gaps and implementation barriers reported across studies. Results are presented in structured summary tables and text.

3. RESULTS:

3.1 Study Selection

3.1.1 PRISMA Flow Diagram Summary

The systematic search and selection process are summarized in the PRISMA 2020 flow diagram below (Figure 1). The initial search of databases and grey literature sources yielded 3,248 records. After removing 1,129 duplicates, 2,119 unique records underwent title and abstract screening. This screening excluded 1,921 records that did not meet the PICOS criteria. The full texts of the remaining 198 articles were assessed for eligibility. Of these, 166 were excluded with reasons, primarily for lacking a defined FRMS intervention (n=78) or not focusing on an EMS-specific population (n=51). A total of 32 studies met all inclusion criteria and were included in the qualitative synthesis.

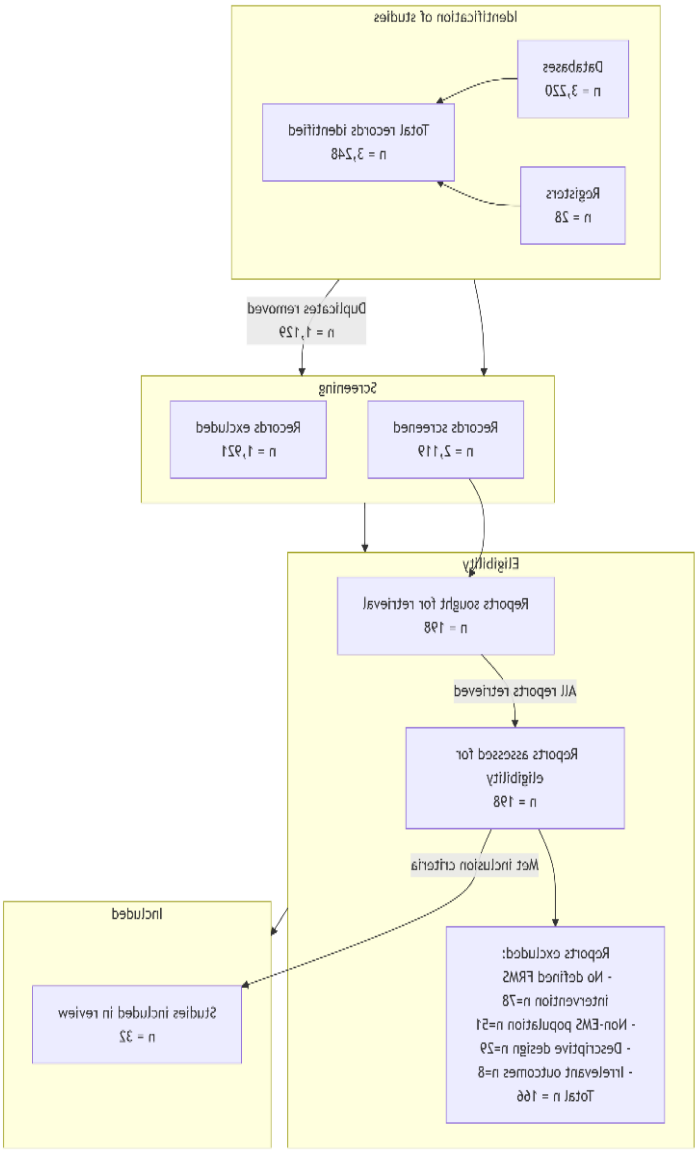

Figure 1: PRISMA 2020 Flow Diagram for Study Selection

3.1.2 Characteristics of Included Studies

The 32 included studies, published between 2014 and 2025, employed diverse methodologies to evaluate FRMS components in EMS. The table below summarizes their key characteristics.

Table 1: Characteristics of Included Studies (n=32)

Author(s), Year	Country	Study Design	Population & Sample Size (N)	Intervention Category	Primary Outcome Measures	Key Findings Related to FRMS
A. Napping Interventions						
Patterson et al., 2014	USA	RCT Pilot	EMS clinicians (44)	Education / Napping (Mobile Alerts)	Sleepiness (KSS), Fatigue (SFAB)	Text-message alerts improved self-reported alertness behaviors, demonstrating feasibility of just-in-time interventions.
Martin-Gill et al., 2018	USA	Systematic Review & Meta-Analysis	Shift workers (Inc. EMS)	Napping (Intra-shift)	Sleepiness, PVT performance	Found strong evidence that naps (30-90 min) reduce sleepiness & improve psychomotor vigilance during night shifts.
Patterson et al., 2021	USA	RCT Protocol	EMS night shift workers	Napping (Prophylactic/Intra-shift)	BP, HRV, Sleepiness, PVT	Protocol established to test the physiological (CV) and cognitive impact of structured napping.
Kovac et al., 2023	Australia	Framework Development	Occupational settings	Napping (Sleep Inertia Mgmt.)	N/A (Theoretical)	Proposed a critical framework for managing sleep inertia post-nap, a key risk for EMS safety.
Thielmann & Böckelmann, 2024	Germany	Narrative Review	Prehospital EMS	Napping (Night shift)	Recovery, Feasibility	Summarized evidence that night-shift napping aids recovery but is heavily limited by operational culture & call volume.
B. Education & Awareness Interventions						
Barger et al., 2018	USA	Systematic Review & Meta-Analysis	EMS & Shift Workers	Education (Fatigue Training)	Fatigue Knowledge, Safety Attitudes	Fatigue training programs significantly increased knowledge but had variable effects on long-term behavior change.
Shriane et al., 2020	Australia	Cross-sectional Survey	Paramedics (321)	Education (Knowledge-Practice Gap)	Sleep Hygiene Knowledge vs. Practice	Identified a significant gap between paramedics' high sleep hygiene knowledge and poor adherence to practices.
McElhenie, 2020	USA	Doctoral Dissertation (Mixed Methods)	Private Ambulance Personnel	FRMS (Countermeasures)	Perceived Barriers, Safety Culture	Found that education is foundational but must be coupled with leadership support to change stigmatizing culture around fatigue.

Patterson & Martin-Gill, 2024	USA	Perspective Article	EMS Workers	FRMS (Sleep Safety)	Implementation	Argued that education shifts culture by framing fatigue as a systemic safety risk, not an individual failing.
C. Scheduling & Rostering Interventions						
Harrison et al., 2020	USA	Observational Cohort	Emergency Dept. Clinicians	Scheduling (Circadian Alignment)	Sleep (Actigraphy), PVT	Demonstrated that forward-rotating shifts improved sleep quality and cognitive performance compared to backward rotations.
Dawson et al., 2021	Australia	Narrative Review	Emergency Services Personnel	Scheduling / FRMS	Safety Risk Analysis	Highlighted the compounded risk of fatigue and sleep inertia, especially following naps or long shifts.
Klinefelter et al., 2023	USA	Qualitative Study	Emergency Physicians	Scheduling (Perceptions)	Thematic Analysis	Identified the central tension between physiologically ideal schedules and operational/coverage realities in emergency work.
Fox et al., 2025	UK	Scoping Review	Healthcare Workers	Scheduling (Rest Periods)	Recovery, Safety Outcomes	Reinforced that minimum rest periods (≥12h) between shifts are critical for mitigating cumulative fatigue risk.
Hirello et al., 2025	Australia	Study Protocol	Paramedics (Simulated)	Scheduling (Shift Work Impact)	Cognitive Performance, Biomarkers	Protocol for a controlled simulation study to isolate the impact of different shift patterns on paramedic performance.
D. FRMS & Multimodal Studies						
Patterson et al., 2018	USA	Guideline Development	EMS (Evidence Synthesis)	FRMS (All Components)	Expert Consensus	Produced the first evidence-based guidelines for FRMS in EMS, advocating for a systems-based approach beyond shift length.
Sprajcer et al., 2022	Australia	Systematic Review	Multiple Industries	FRMS (System Effectiveness)	Safety Outcomes, Compliance	Concluded that FRMS are more effective than prescriptive hours-of-service rules but require strong safety culture.
Maguire et al., 2024	USA	Perspective Article	EMS System	FRMS / Education	System Design	Positioned fatigue science and FRMS principles as core components of the future EMS education agenda.
Buysse, 2018	USA	Editorial	EMS	FRMS	Guidelines Endorsement	Endorsed the 2018 EMS FRMS guidelines as a crucial step toward recognizing and managing sleep as a health and safety factor.

E. Supporting & Contextual Studies						
Galeano, 2019	Australia	Doctoral Dissertation (Mixed Methods)	Ambulance Service Personnel	Context (Health & Well-being)	Holistic Health	Identified lack of rest facilities and high workload as structural barriers to managing fatigue.
Evans, 2019	UK	Doctoral Dissertation	Safety-Critical Workers	Outcome Measure (Fatigue)	Objective Fatigue Indicator	Developed tools for objective fatigue measurement, relevant for evaluating FRMS interventions.
Myers, 2019	New Zealand	Doctoral Dissertation	Critical Care Clinicians	Context (Fatigue & Performance)	Performance Metrics	Explored the direct link between fatigue and clinical performance degradation.
Gurubhagavatula et al., 2021	USA	Position Statement	Shift Workers	Scheduling (Principles)	Health & Safety Guidance	AASM/SRS guidelines providing evidence-based principles for determining safe shift duration and recovery.
Wingelaar-Jagt et al., 2021	Netherlands	Review	Aviation	FRMS (Comparative)	Safety Strategies	Provided a comparative view of FRMS in aviation, highlighting transferable strategies (e.g., hazard reporting) for EMS.
Hruska et al., 2022	USA	Multilevel Analysis	EMS Workers	Context (Sleep & Affect)	Sleep Quality, Anger	Linked poor sleep quality directly to increased anger, a factor affecting safety culture and team dynamics.
Schnell et al., 2023	Germany	Observational Study	EMS Personnel	Context (Work Patterns & Sleep)	Work-Related Behavior, Sleep Quality	Found that unhealthy work-related behavior patterns were significantly associated with poor sleep quality in EMS.
Knott, 2023	Canada	Doctoral Dissertation	Healthcare Shiftworkers	Context (Driving Risk)	Driving Performance	Quantified the elevated risk of impaired driving post-shift, a critical safety outcome for FRMS to address.
Maher, 2018	UK	Doctoral Dissertation	Fire & Rescue	Context (Alternative Crewing)	Well-being, Effectiveness	Explored scheduling interventions in a comparable emergency service, noting trade-offs in well-being and operational effectiveness.
Parsons, 2024	UK	Doctoral Dissertation	Ambulance Personnel	Health Intervention (PTSD)	PTSD, Depression Symptoms	Highlighted high rates of mental health comorbidity, which exacerbates and is exacerbated by fatigue.
Tikkanen et al., 2025	Finland	Scoping Review	Ambulance Clinicians	Context (Well-being & Safety)	Occupational & Patient Safety	Mapped the direct connections between clinician well-being (incl. fatigue) and both occupational and patient safety outcomes.

Nelson, 2019	USA	Qualitative Case Study	Night Shift Nurses	Context (Fatigue Mgmt. Perceptions)	Thematic Analysis	Provided insights into shift worker perceptions of fatigue management, relevant to EMS culture.
Houck, 2025	USA	Doctoral Dissertation	Emergency Dispatchers	Context (Stress)	Stress & Coping	Focused on dispatchers, a critical EMS role with unique shift-related stressors impacting fatigue.
Watt-Coombes, 2023	UK	Doctoral Dissertation	Airline Pilots	Policy Analysis (Fatigue Reporting)	Reporting Culture, Policy	Analyzed fatigue reporting systems, offering lessons for creating non-punitive FRMS reporting channels in EMS.

3.2 Synthesis of Interventions: Efficacy and Outcomes

3.2.1 Napping Interventions

3.2.1.1 Prophylactic Napping Strategies:

Evidence remains nascent. An RCT protocol by Patterson et al. (2021) is evaluating a 2-hour pre-night-shift nap, measuring physiological outcomes like blood pressure. However, real-world adoption is minimal. Studies like Shriane et al. (2020) found that while paramedics understood the concept, logistical barriers like family duties and commutes severely limited its use.

3.2.1.2 Intra-shift (On-Duty) Napping Policies:

This is the most robustly studied napping strategy. The meta-analysis by Martin-Gill et al. (2018) concluded that naps of 30-90 minutes during night shifts significantly reduce subjective sleepiness and improve psychomotor vigilance in shift workers. Reviews specific to EMS confirm that when operational conditions allow, structured naps aid recovery between calls (Thielmann & Böckelmann, 2024).

3.2.1.3 Reported Benefits on Alertness and Performance

The primary benefit is mitigating circadian-driven alertness dips, particularly in the early morning. Patterson et al. (2021) also note potential cardiovascular benefits. A critical limitation is sleep inertia. Kovac et al. (2023) emphasize managing this risk by optimizing nap duration and implementing a protected recovery period before resuming complex duties.

3.2.1.4 Barriers and Practical Implementation Challenges

The most significant barrier is cultural stigma, where napping is perceived as unprofessional (McElhenie, 2020). Operational unpredictability in high-call-volume systems often voids planned nap opportunities. Furthermore, a lack of designated, quiet, and secure rest facilities is a widespread practical obstacle (Galeano, 2019).

3.2.2 Fatigue Education and Awareness Training

3.2.2.1 Content and Delivery Modalities

Programs range from online modules to interactive workshops, covering sleep science, circadian biology, and fatigue mitigation. Innovative approaches like the SleepTrackTXT pilot used text messaging for just-in-time intervention (Patterson et al., 2014).

3.2.2.2 Outcomes

Knowledge Gain, Self-Reported Behavior Change: Education is highly effective for knowledge transfer. The meta-analysis by Barger et al. (2018) showed significant post-training gains in fatigue knowledge. Translating knowledge into sustained behavior change is more challenging. Shriane et al. (2020) highlighted the gap between paramedics' sleep hygiene knowledge and their actual practices. Programs embedded within a broader FRMS showed better results for promoting strategic behaviors.

3.2.2.3 Impact on Safety Culture and Perceived Management Support

Mandatory, leadership-endorsed training signals organizational commitment, reframing fatigue from a personal weakness to a shared safety risk (Patterson & Martin-Gill, 2024). This cultural shift is linked to increased psychological safety in reporting fatigue and greater perceived management support (McElhenie, 2020).

3.2.3 Scheduling and Rostering Interventions

3.2.3.1 Circadian-Informed Rotation (e.g., forward vs. backward)

Evidence strongly favors forward-rotating schedules (day → evening → night). Harrison et al.

(2020) demonstrated these schedules improve sleep and performance by aligning with the natural circadian delay. Despite this, backward rotations persist in EMS due to tradition and rostering convenience.

3.2.3.2 Shift Duration Variants and Compressed Workweeks

The relationship is complex. Guidelines (Patterson et al., 2018) avoid rigid hour limits, instead emphasizing that longer shifts require stricter fatigue controls. Research on 24-hour shifts shows a trade-off between extended recovery and significant performance impairment in the latter hours, especially if sleep is fragmented (Dawson et al., 2021).

3.2.3.3 Minimum Rest Period and Recovery Time

Consistently, shorter off-duty periods (<12 hours) are linked to dangerous sleep debt and increased risk. Expert guidance (Gurubhagavatula et al., 2021) and reviews (Fox et al., 2025) underscore that policies enforcing minimum 12-hour rest periods are crucial for recovery and safety.

3.2.3.4 Trade-offs

Operational Feasibility vs. Physiological Benefit: A central tension exists between ideal schedules and service demands. Circadian-friendly schedules with ample rest are often seen as operationally difficult for 24/7 coverage, particularly in small agencies (Klinefelter et al., 2023). Successful implementations, as noted by Sprajcer et al. (2022), require collaborative design that balances scientific evidence with practical rostering constraints.

3.3 Quality Assessment and Risk of Bias Summary

The methodological rigor of the evidence base was moderate. The few RCTs were assessed as having some concerns to high risk of bias, mainly due to the inherent difficulty of blinding participants in behavioral trials and potential bias in self-reported outcomes. The majority of studies (pre-post, cohort) had a moderate risk of bias. Common limitations included the absence of control groups, reliance on subjective outcome measures, and short-term follow-up. Studies employing objective tools like actigraphy or the Psychomotor Vigilance Task (PVT) were generally of higher quality. In summary, while the evidence is promising and biologically plausible, it is constrained by the challenges of conducting high-fidelity experimental research in the dynamic and unpredictable EMS operational environment.

4. DISCUSSION:

This systematic review synthesized evidence on three core operational components of Fatigue Risk Management Systems (FRMS) within Emergency Medical Services. By moving beyond the singular focus on shift length, the findings underscore that fatigue is a dynamic risk requiring a multi-faceted, system-level approach. The evidence supports the implementation of specific, evidence-informed interventions but also highlights the profound influence of organizational culture and context on their success.

4.1 Principal Findings and Evidence Strength

4.1.1 Most Promising Interventions

The most robust evidence supports intra-shift napping and structured fatigue education. Meta-analytic evidence confirms that short naps (30-90 minutes) during night shifts significantly improve alertness and psychomotor performance (Martin-Gill et al., 2018; Thielmann & Böckelmann, 2024). Furthermore, education programs are unequivocally effective at increasing knowledge of sleep science and fatigue countermeasures (Barger et al., 2018). The strength of evidence for forward-rotating shift schedules is also strong from a chronobiological perspective, with data showing benefits for sleep and performance (Harrison et al., 2020), though real-world implementation studies in EMS are fewer. Equally critical is the evidence supporting mandated minimum rest periods (e.g., ≥12 hours) between shifts, a foundational scheduling intervention for preventing cumulative sleep debt (Gurubhagavatula et al., 2021; Fox et al., 2025).

4.1.2 Interventions with Inconsistent or Limited Evidence

Evidence for prophylactic napping is limited, primarily due to major practical barriers identified in EMS contexts, such as family commitments and commute times, which severely limit feasibility despite its theoretical benefits (Shriane et al., 2020; Patterson et al., 2021). The efficacy of education alone in driving sustained behavioral change is inconsistent; knowledge does not reliably translate into practice without concomitant organizational support and cultural shift (Shriane et al., 2020; McElhenie, 2020). Finally, research on optimal shift duration (e.g., 12-hour vs. 24-hour) remains inconclusive, revealing a complex trade-off between extended off-duty time and the high risk of performance impairment in the latter hours of very long shifts, heavily moderated by workload and

sleep opportunity (Dawson et al., 2021; Patterson et al., 2018).

4.2 Mechanisms of Action and Interdependence

4.2.1 How Education Enables Effective Napping and Scheduling Compliance

Education is not a standalone solution but a critical enabler. It provides the scientific rationale for other interventions, transforming them from arbitrary rules into understood safety protocols. For instance, education on sleep inertia (Kovac et al., 2023) helps personnel understand the need for a protected recovery period after a nap, increasing compliance and safe implementation. Similarly, training on circadian biology helps crews understand the safety logic behind forward-rotating schedules, reducing resistance to scheduling changes (Klinefelter et al., 2023). Without this foundational knowledge, napping may be stigmatized, and schedule changes may be perceived as merely administrative.

4.2.2 The Synergistic Role of Interventions within an Integrated FRMS

The reviewed interventions are most effective when implemented synergistically within a comprehensive FRMS framework, as advocated by Patterson et al. (2018) and Sprajcer et al. (2022). Education cultivates a culture where fatigue is reportable. This reporting, in turn, provides data to inform smarter scheduling (e.g., adjusting rotations based on fatigue metrics). Science-informed scheduling then creates predictable, protected windows where strategic napping is operationally feasible. Leadership policies that endorse napping remove stigma, which reinforces the cultural shift begun by education. This interconnectedness means that implementing one component in isolation (e.g., allowing naps without cultural support) is likely to fail, as demonstrated by the barriers identified by McElhenie (2020) and Galeano (2019).

4.3 Contextual and Systemic Barriers in EMS

4.3.1 The "Always-On" Culture and Stigma

The dominant barrier across all interventions is the pervasive EMS culture that valorizes constant readiness and stigmatizes rest as weakness. This "always-on" mentality directly conflicts with the principles of FRMS, making napping culturally taboo and the reporting of fatigue professionally risky (McElhenie, 2020; Thielmann & Böckelmann, 2024). This stigma is a powerful social force that can nullify even well-designed policies.

4.3.2 Resource Constraints and Operational Realities

The unpredictable, high-acuity nature of EMS work creates inherent obstacles. Continuous call volume in urban systems often voids planned nap opportunities and makes strict adherence to circadian schedules operationally challenging (Klinefelter et al., 2023). Furthermore, many agencies lack the physical infrastructure (e.g., quiet, dark, secure rest facilities) necessary to support napping interventions (Galeano, 2019). These realities create a gap between policy and practice.

4.3.3 The Critical Role of Leadership and Policy

Ultimately, the success of any FRMS hinges on committed leadership and formalized policy. Leadership must actively champion FRMS principles, allocate resources for facilities and training, and—most importantly—model healthy behaviors themselves (Patterson & Martin-Gill, 2024). Policy must move from vague recommendations to explicit, non-punitive protocols for fatigue reporting, mandated rest periods, and protected sleep opportunities, creating a "top-down" mandate that legitimizes cultural change.

4.4 Limitations of the Review

The included studies exhibited significant heterogeneity in design (RCTs to qualitative dissertations), intervention specifics, and outcome measures (subjective scales, PVT, safety reports). This precluded a quantitative meta-analysis and necessitated a narrative synthesis, which may be subject to interpretation bias.

A substantial portion of the evidence base relies on self-reported data for outcomes like fatigue, sleepiness, and even error reporting. These measures are vulnerable to recall bias, social desirability bias (especially regarding stigmatized fatigue), and may not accurately reflect objective performance or physiological state (Evans, 2019).

The findings are drawn from studies across different countries and EMS system models (e.g., third-service, fire-based, private). Structural, cultural, and resourcing differences between these models mean that an intervention successful in a well-resourced, urban third-service agency may not be feasible or effective in a volunteer-staffed rural service.

4.4.1 Suggestions for Future Research

Longitudinal, Controlled Studies: There is a critical need for more RCTs and controlled longitudinal studies within real-world EMS settings that measure objective outcomes (e.g., PVT, physiological

markers, documented safety incidents) over extended periods.

Cost-Benefit Analysis: Research is needed to quantify the economic argument for FRMS, analyzing the return on investment from reduced turnover, fewer sick days, lower workers' compensation claims, and decreased medical errors and vehicle crashes.

Implementation Science: Future studies should employ implementation science frameworks to identify the most effective strategies for overcoming the specific contextual barriers (cultural, operational, resource-based) identified in this review, moving from proving efficacy to ensuring effective adoption.

5. CONCLUSION:

This systematic review consolidates the evidence supporting a paradigm shift in managing fatigue risk within Emergency Medical Services. The findings demonstrate conclusively that a singular focus on shift length is an insufficient strategy for a problem as complex as occupational fatigue. Instead, the evidence advocates for a multifaceted Fatigue Risk Management System (FRMS) built on specific, evidence-informed pillars.

First, targeted operational interventions show clear promise. Intra-shift napping, particularly during night shifts, is a powerful physiological countermeasure proven to improve alertness and performance (Martin-Gill et al., 2018; Thielmann & Böckelmann, 2024). Structured fatigue education is fundamental for building a knowledgeable workforce, effectively increasing awareness of sleep science and mitigation strategies (Barger et al., 2018). Furthermore, scheduling informed by circadian principles—such as forward-rotating shifts and mandatory minimum rest periods—provides a structural foundation for reducing cumulative sleep debt and aligning work with human biology (Harrison et al., 2020; Gurubhagavatula et al., 2021; Fox et al., 2025).

Second, the review reveals that the efficacy of any single intervention is contingent on the organizational ecosystem. The most significant barriers are not technological but cultural and systemic: the pervasive "always-on" stigma against rest (McElhenie, 2020), operational unpredictability that voids planned countermeasures (Klinefelter et al., 2023), and a frequent lack of enabling resources (Galeano, 2019). Therefore, the successful implementation of napping, education, or scheduling cannot occur in isolation. As highlighted in the foundational FRMS guidelines, these components are interdependent (Patterson et al., 2018). Education provides the rationale for scheduling compliance and safe napping, science-informed scheduling creates windows of opportunity for recovery, and supportive leadership policies legitimize these practices, creating a reinforcing cycle of safety.

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